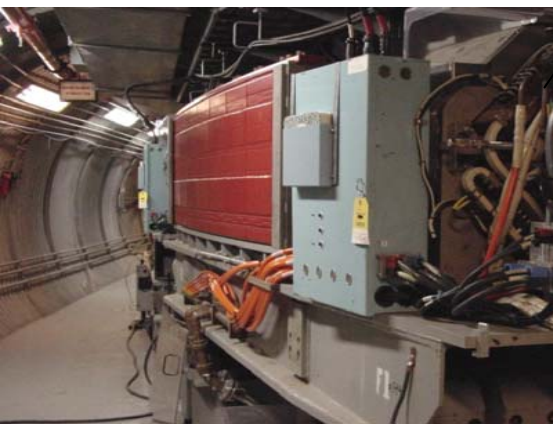
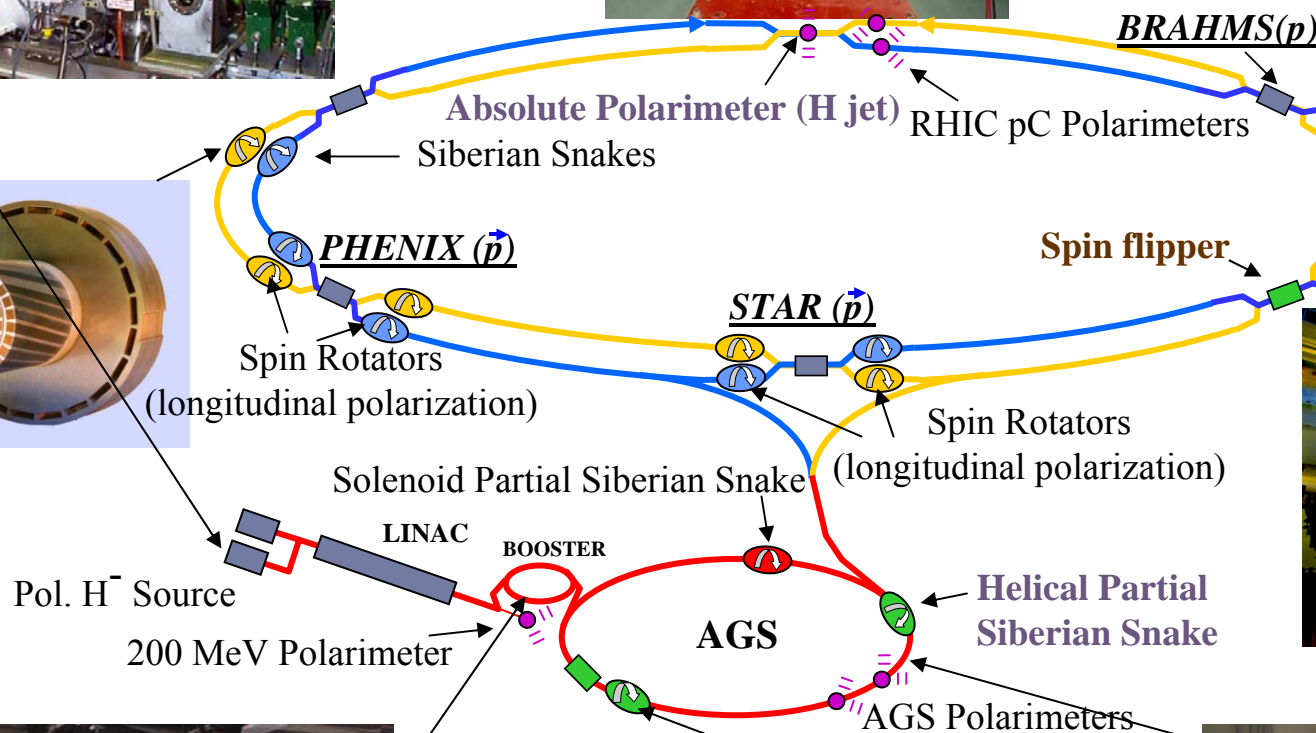
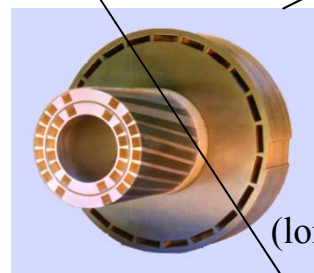


Polarized Protons in RHIC

Mei Bai

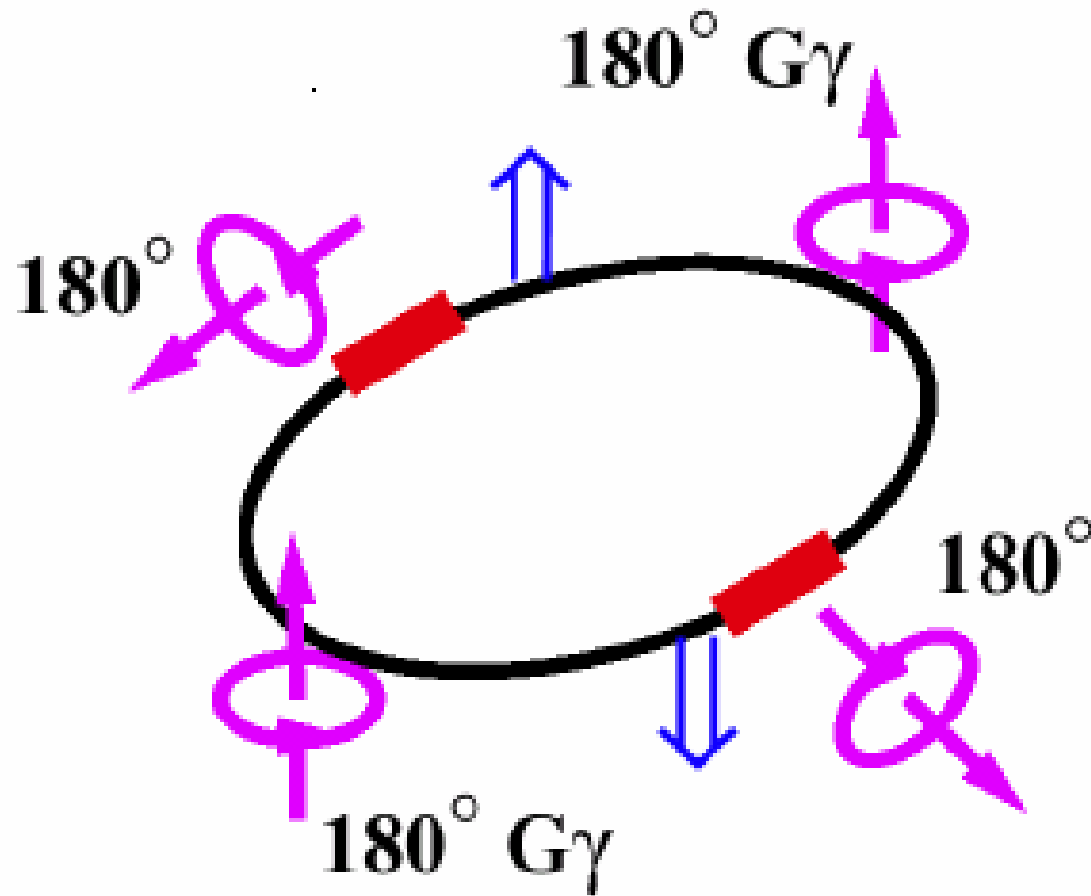
Collider Accelerator Department
Brookhaven National Laboratory



RHIC pp design parameter

Parameter	Unit	p-p
relativistic γ , injection	...	25.9
relativistic γ , store	...	266.5
no of bunches, n_b	...	112
ions per bunch, N_b	10^{11}	2.0
emittance $e_{N\ x,y\ 95\%}$	mm-mrad	20
average luminosity	$10^{30}\text{ cm}^{-2}\text{s}^{-1}$	150
polarization,store	%	70

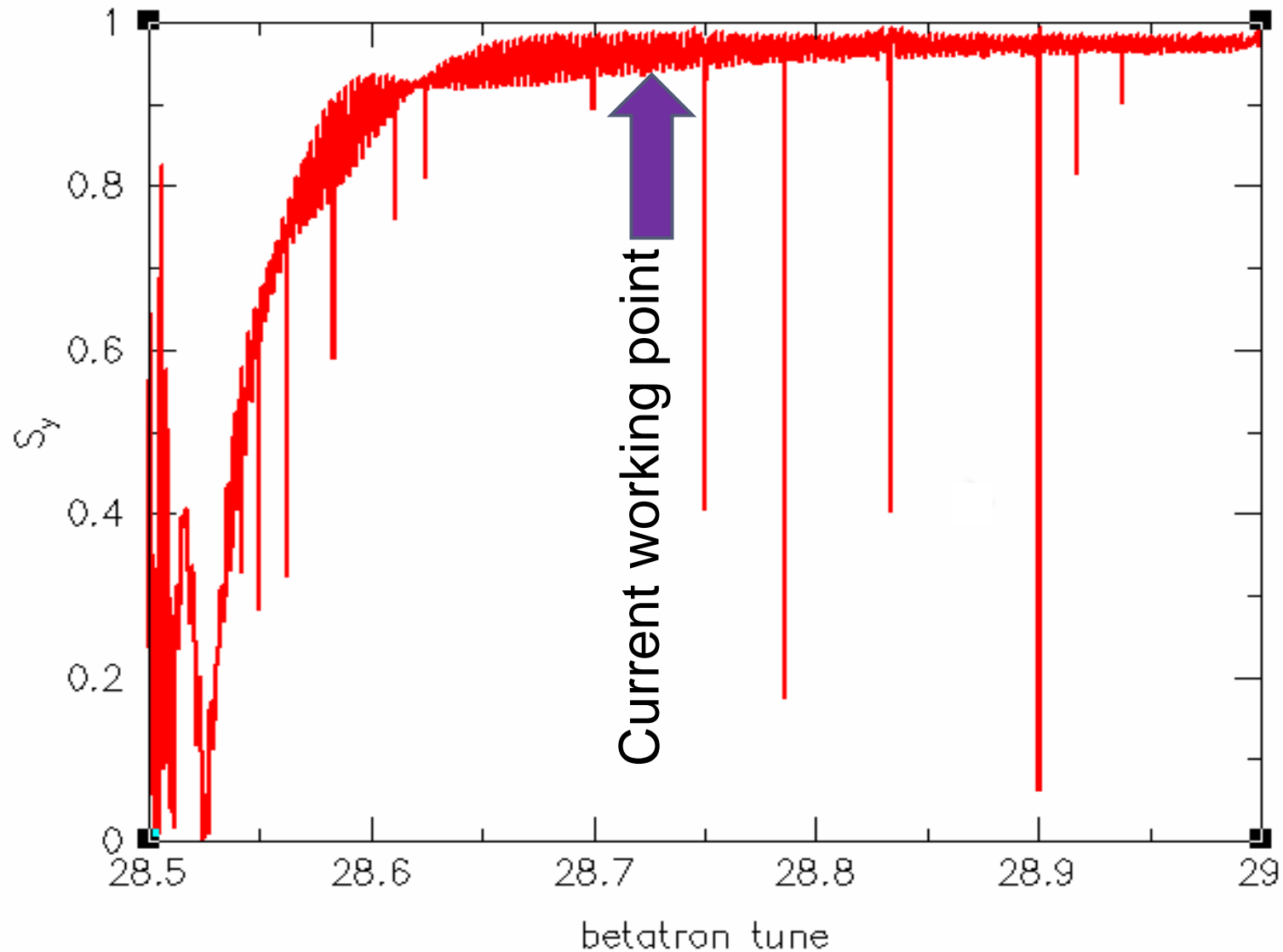
RHIC polarized proton setup



$$Q_s = \frac{1}{\pi} |\varphi_1 - \varphi_2|$$

⇒ $Q_s = \frac{1}{2}$

Preserve polarization in RHIC: working point



Preserve polarization in RHIC:

- ▶ Keep the vertical closed orbit as flat as possible to minimize the snake resonances at

$$2m Q_y = Q_s + k$$

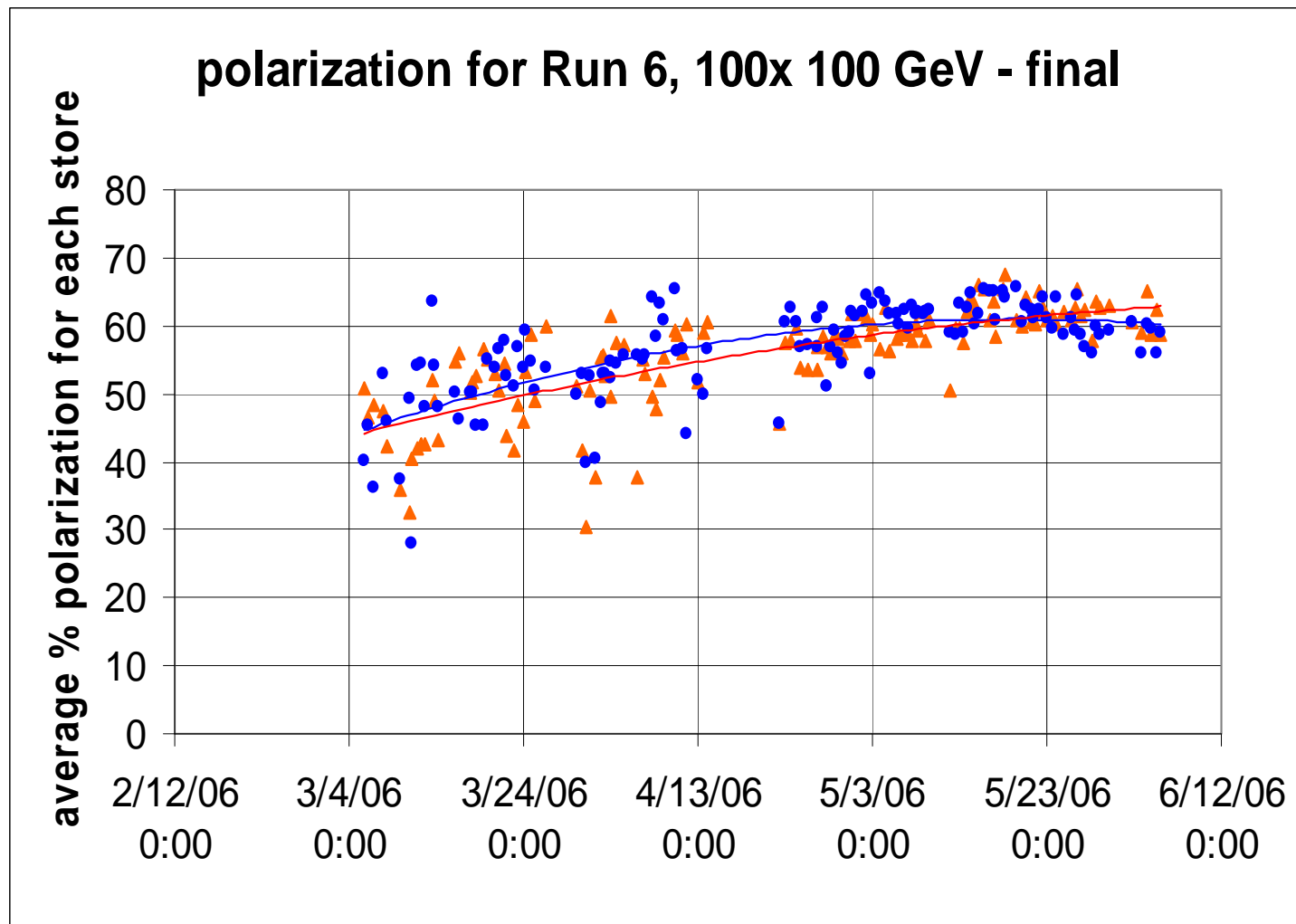
- ▶ Optimize the snake current to get spin tune at $1/2$

RHIC Polarized proton status

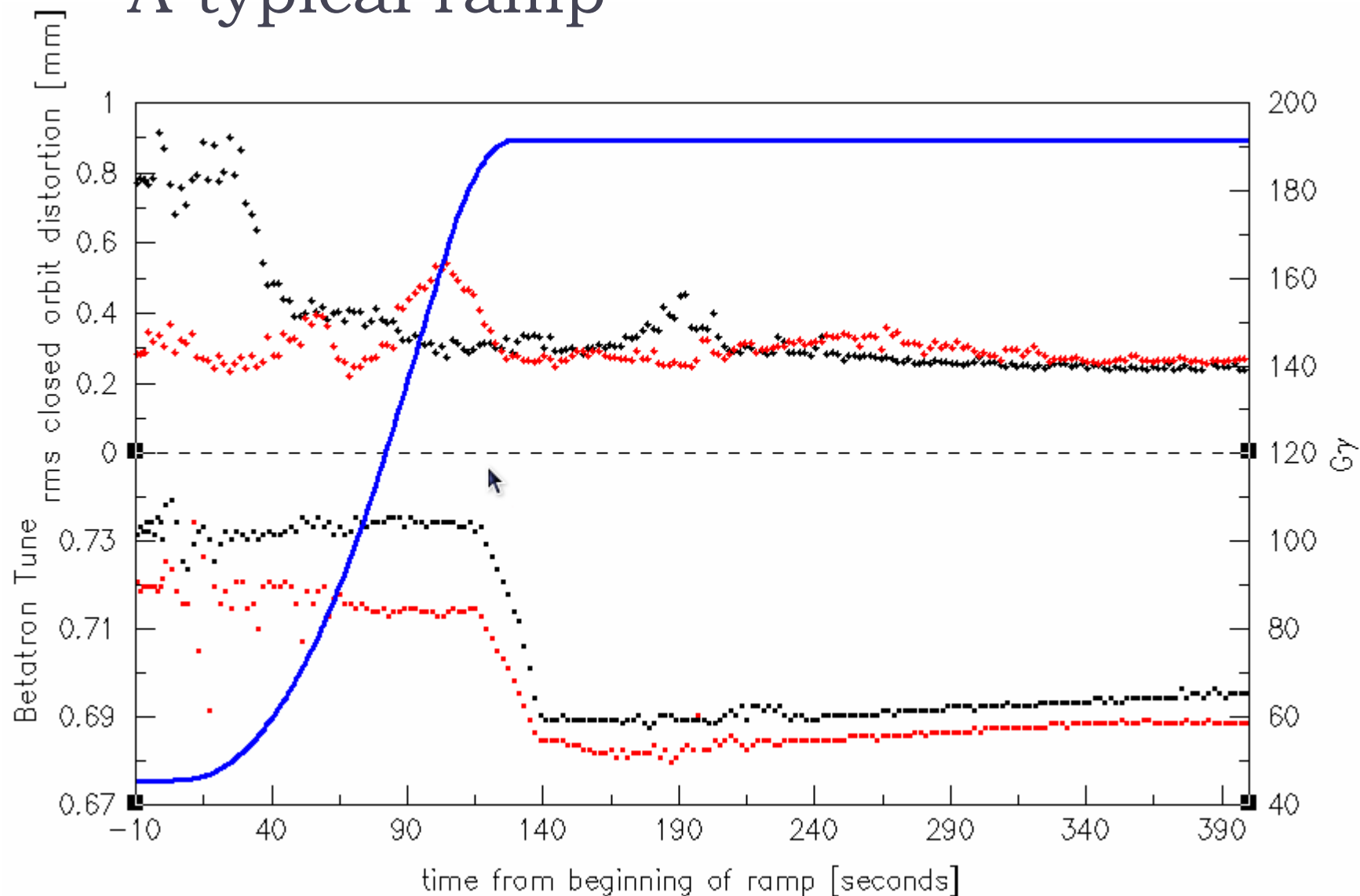
RHIC pp achieved performance

Parameter	Unit	2002	2003	2004	2005	2006
No. of bunches	--	55	55	56	106	111
bunch intensity	10^{11}	0.7	0.7	0.7	0.9	1.3
store energy	GeV	100	100	100	100	100
β^*	m	3	1	1	1	1
peak luminosity	$10^{30}\text{cm}^{-2}\text{s}^{-1}$	2	6	6	10	<u>35</u>
average luminosity	$10^{30}\text{cm}^{-2}\text{s}^{-1}$	1	4	4	6	<u>20</u>
Collision points	--	4	4	4	3	2
Time in store	%	30	41	38	56	46
average polarization, store	%	15	35	46	47	<u>60~65</u>

Achieved polarization in RHIC 2006



A typical ramp



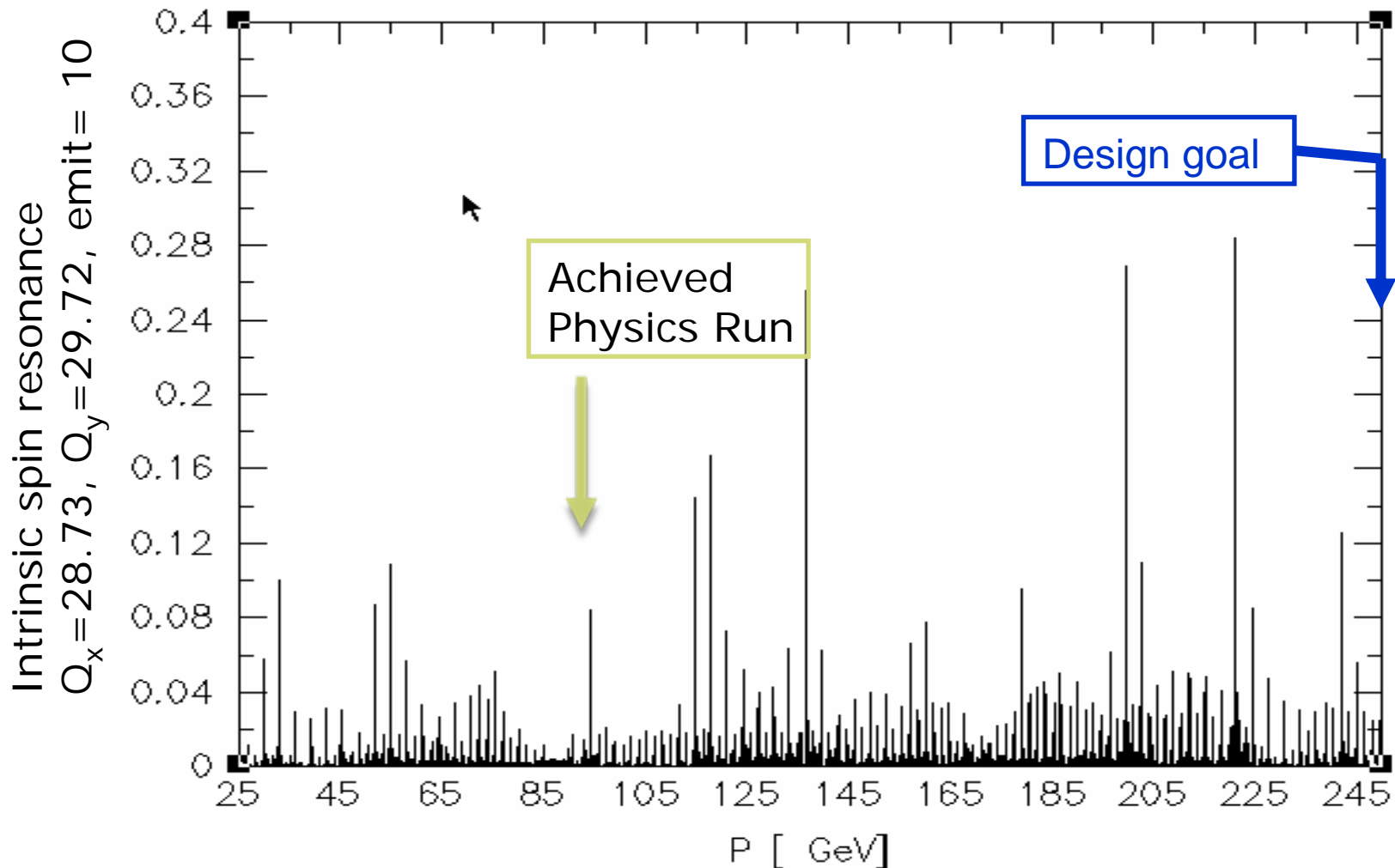
Luminosity performance

- ▶ Need a factor of 3 to achieve the design luminosity goal
- ▶ Current luminosity limit
 - ▶ Beam-beam interaction
 - ▶ Cause emittance growth through non-linear resonance and other effects.
 - ▶ Current pp workpoint at (0.695,0.685) hits the limit by $3Q_x$ resonance and $10Q_{x,y}$
 - ▶ E-cloud: possibly an additional source of emittance growth

Polarization performance

- ▶ Achieved 100% polarization transmission efficiency from injection to 100 GeV
- ▶ Much stronger spin depolarizing resonances from 100 GeV to 250 GeV

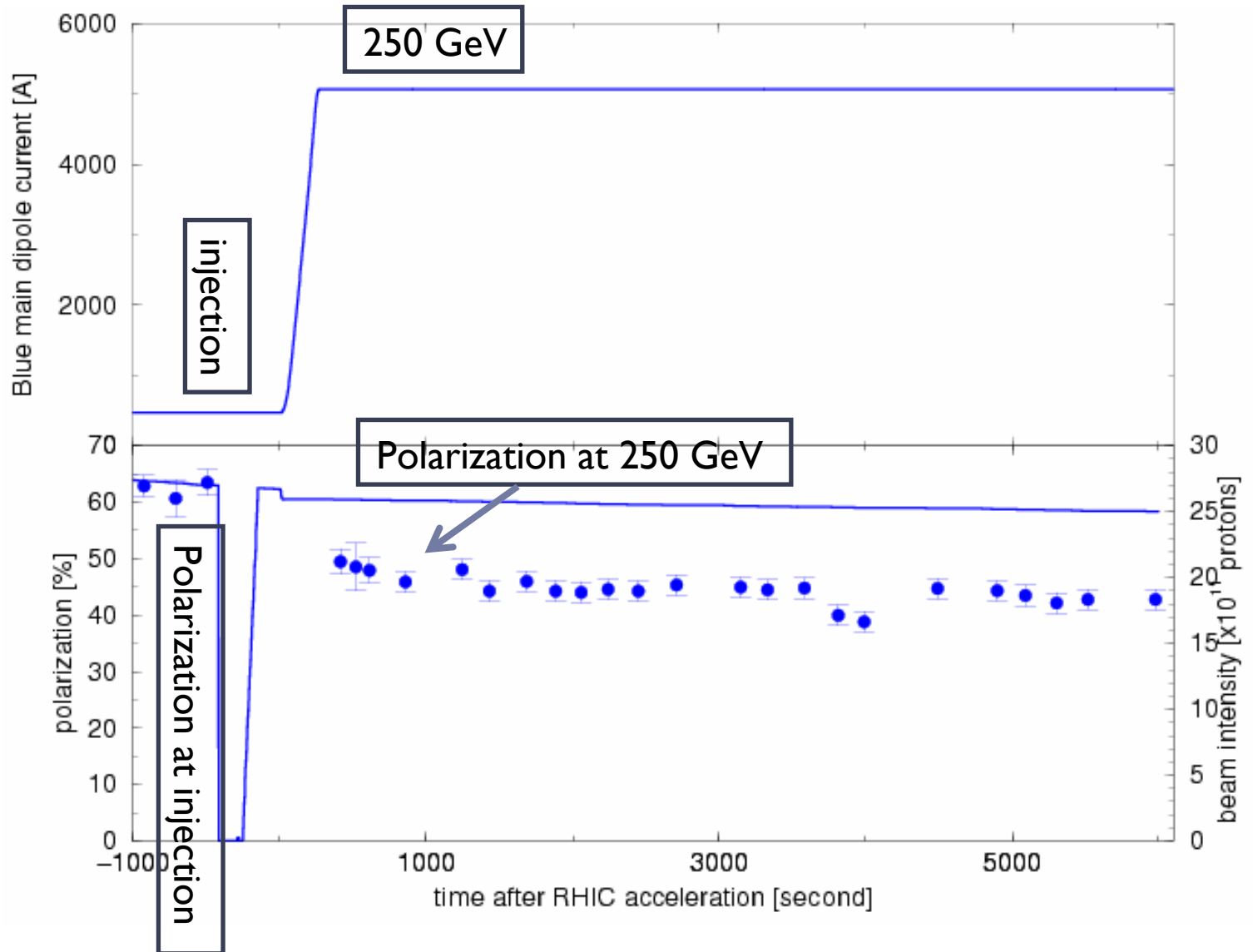
RHIC intrinsic spin resonance spectrum



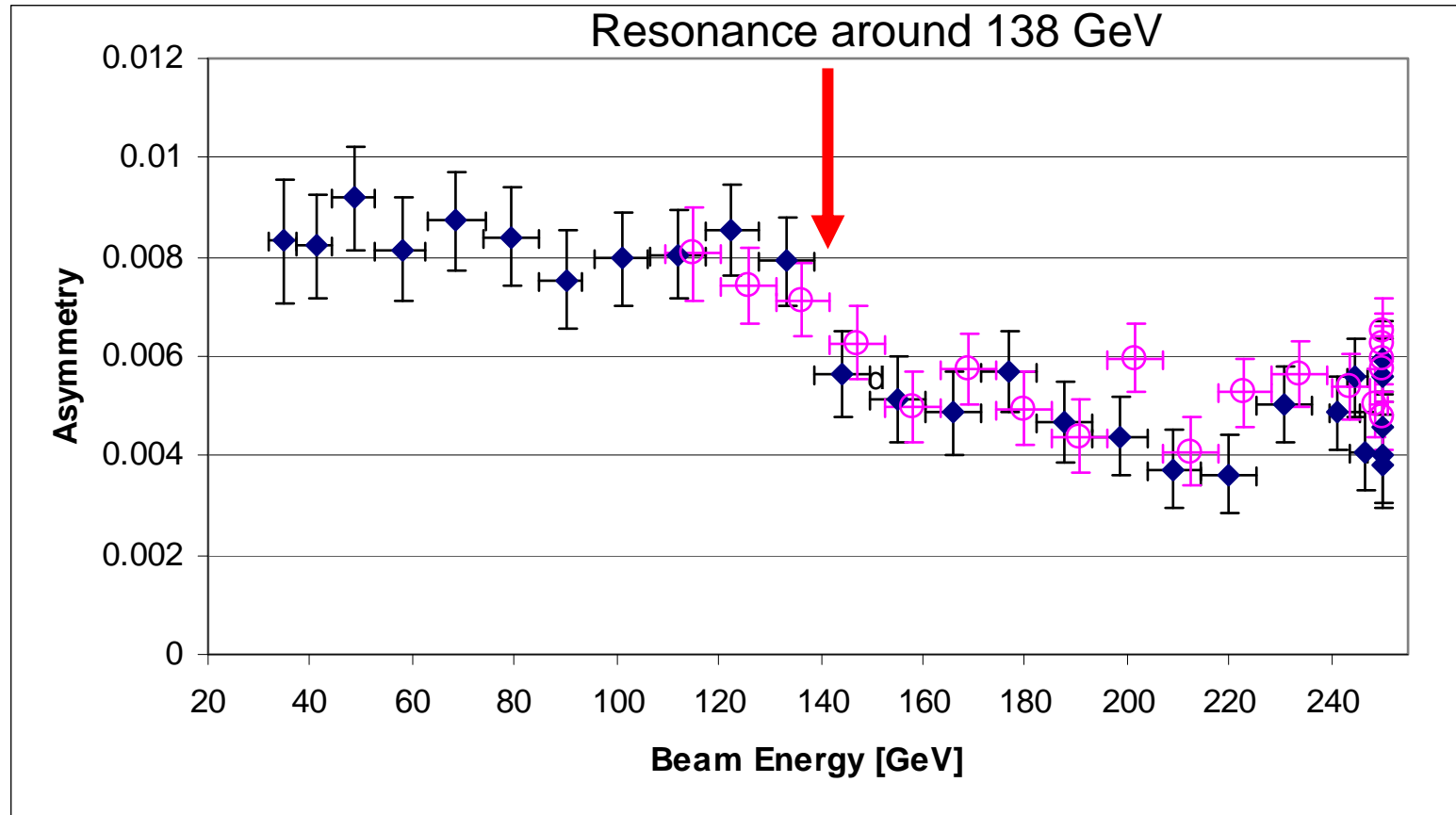
RHIC pp 250 GeV development(one week)

- Explore polarization transmission to a beam energy of 250 GeV
- Inspect the luminosity aspects (with 2 collisions)
 - Store lifetime
 - Total intensity limits

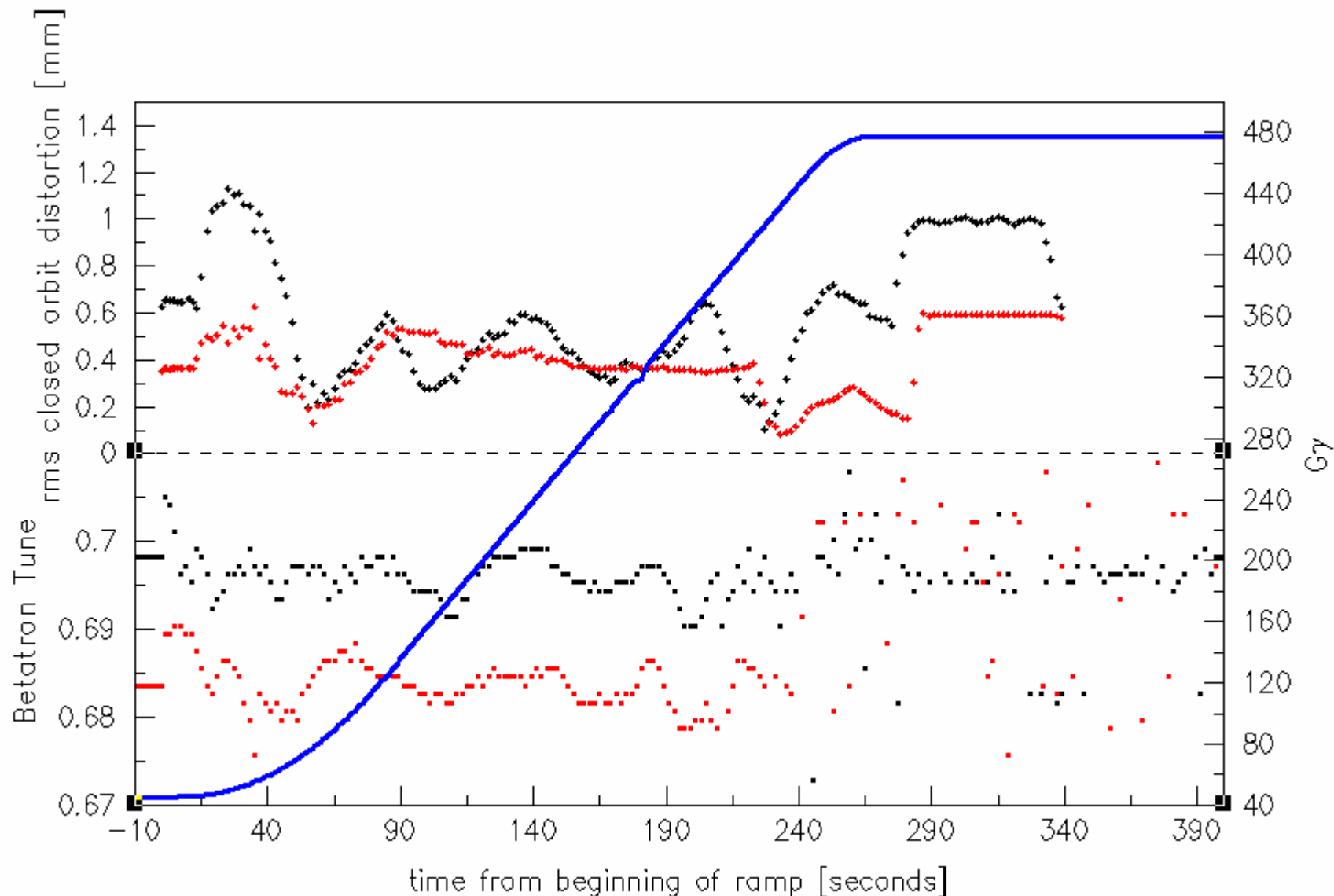
Polarized proton at 250 GeV



RHIC pp polarization ramp measurement



Orbit/Tunes during the 250 GeV acceleration



Remaining issues of RHIC pp 250 GeV development

- Exam the polarization transmission efficiency in Yellow
- Systematic study of polarization along the energy ramp as function of orbit distortion and beam tunes at depolarization resonances beyond 100 GeV
- Establish collisions to study the luminosity aspects at 250 GeV
- Study the polarization lifetime as a function of beam tunes at 250 GeV

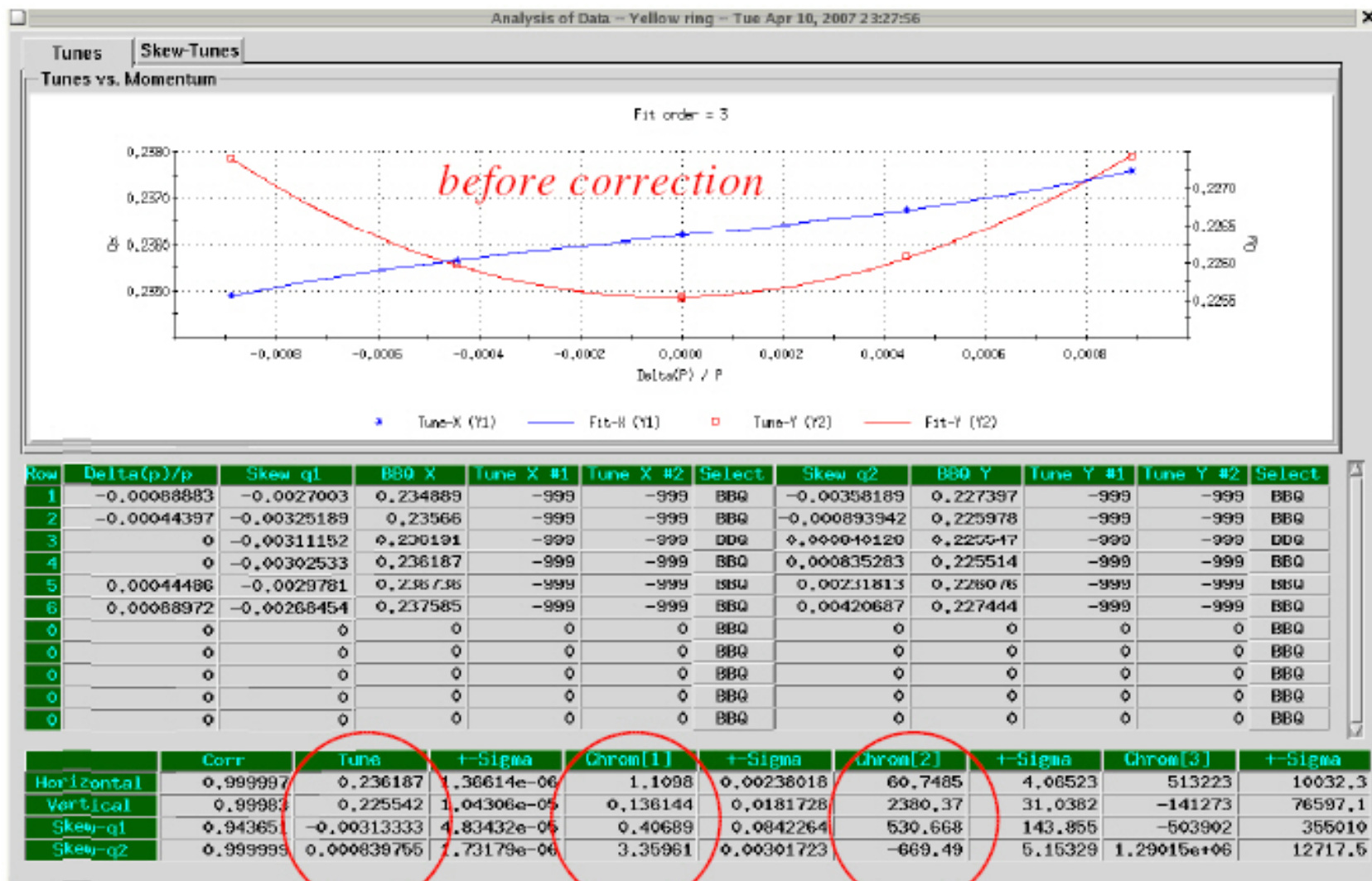
Polarized proton development plan

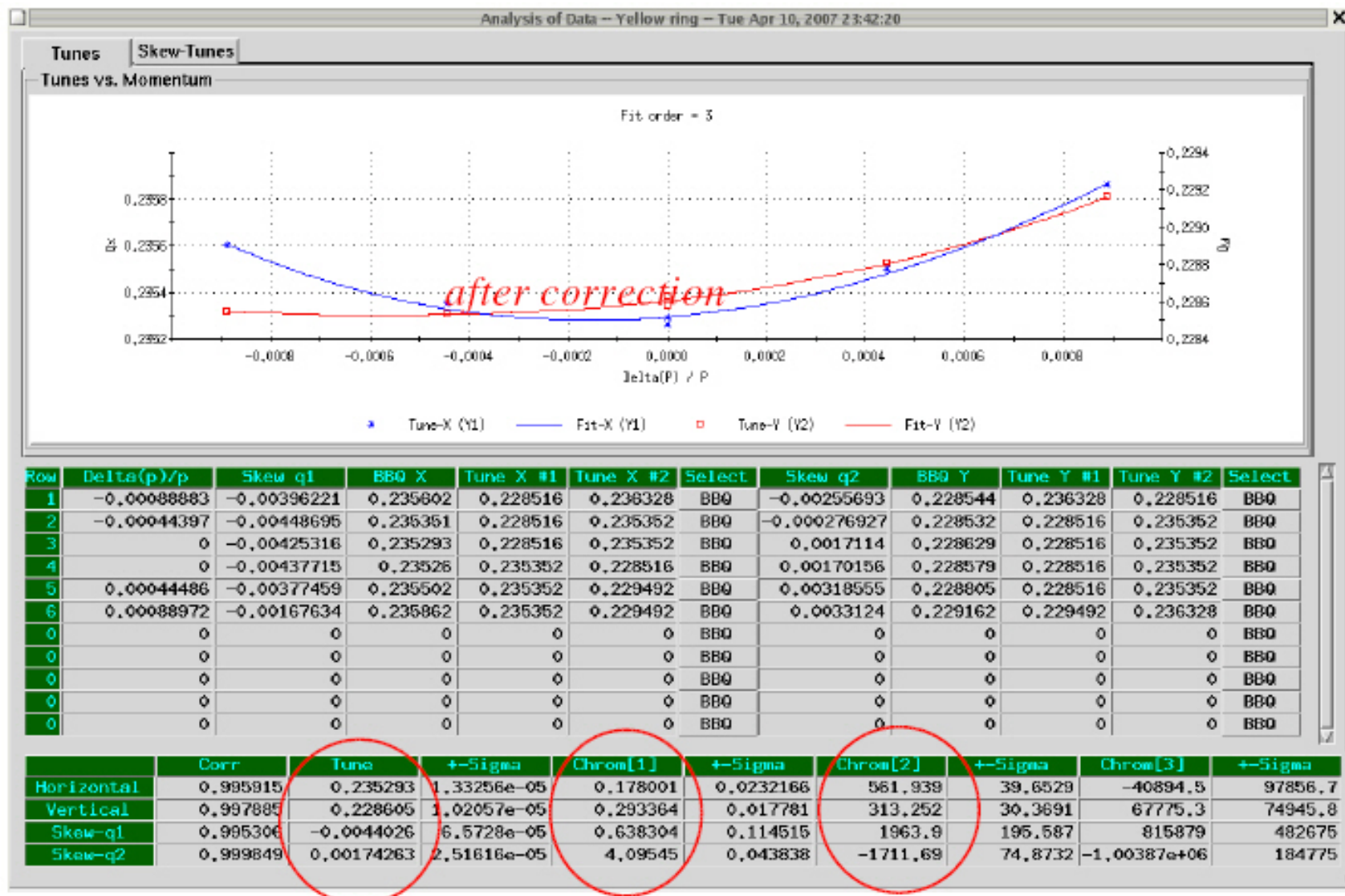
Polarized proton development plan

- ▶ **Luminosity:**

- ▶ Non-linear chromaticity correction: implemented in the current Au-Au Run: Tepikian, Nikolay, Yun

Nonlinear chrom correction with Nikolay's settings





*These settings were found by Nikolay several weeks ago.
They can be used for operation.*

Polarized proton development plan

- ▶ **Luminosity:**

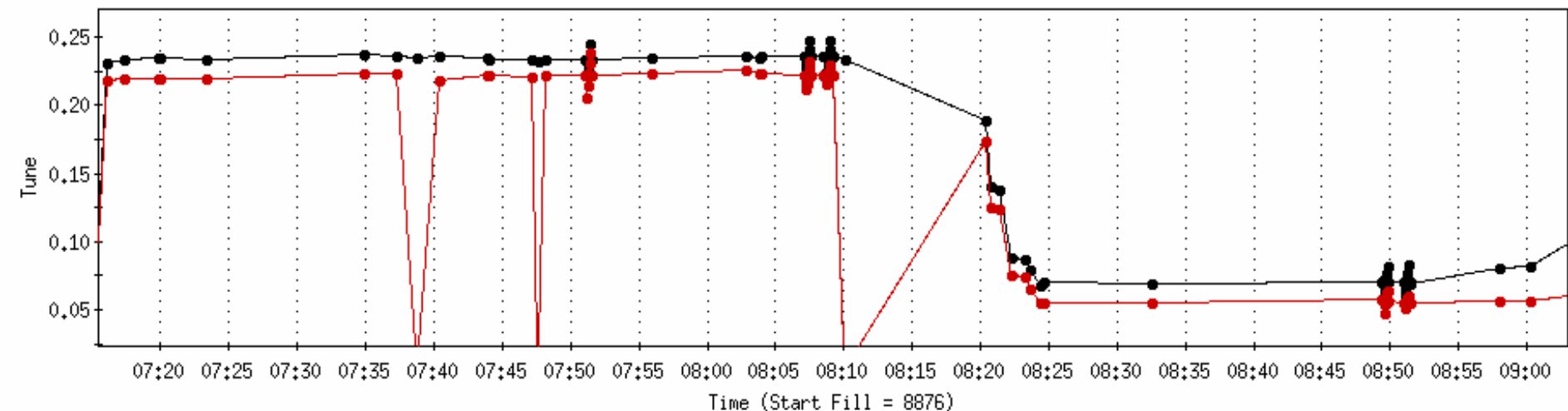
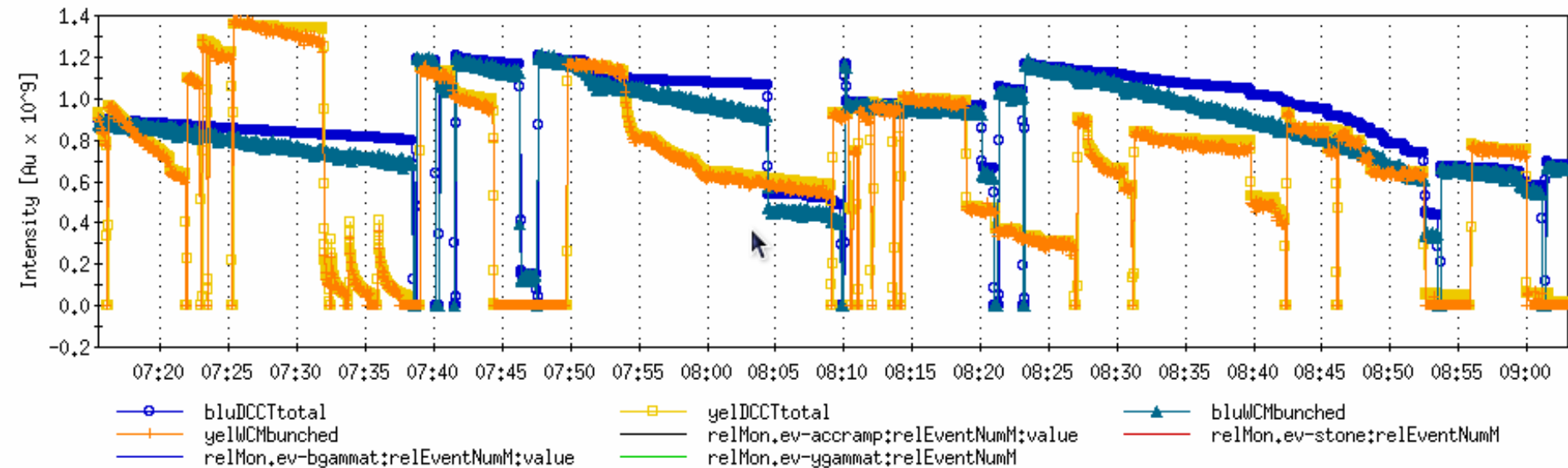
- ▶ Non-linear chromaticity correction: implemented in the current Au-Au Run
- ▶ 3Qx resonance correction: under study by Johan, Yun, Rama, Mei, ...

Polarized proton development plan

► Luminosity:

- Non-linear chromaticity correction: implemented in the current Au-Au Run
- 3Qx resonance correction: under study
- Explore new working point at (0.08, 0.07)
 - Team: Christoph, Wolfram, Yun, Mei, Luccio, ...
 - DA tracking: good dynamic aperture
 - Spin tracking: Good spin transmission efficiency
 - Tested with Au beam during the current Au run at injection
 - Achieved good beam lifetime at injection at (0.07,0.05)
 - Able to correct the orbit at these tunes
 - This will be first commissioned during the 2008 pp 100GeV run

Integer tune beam experiment with Au beam



Polarized proton development plan

▶ Luminosity:

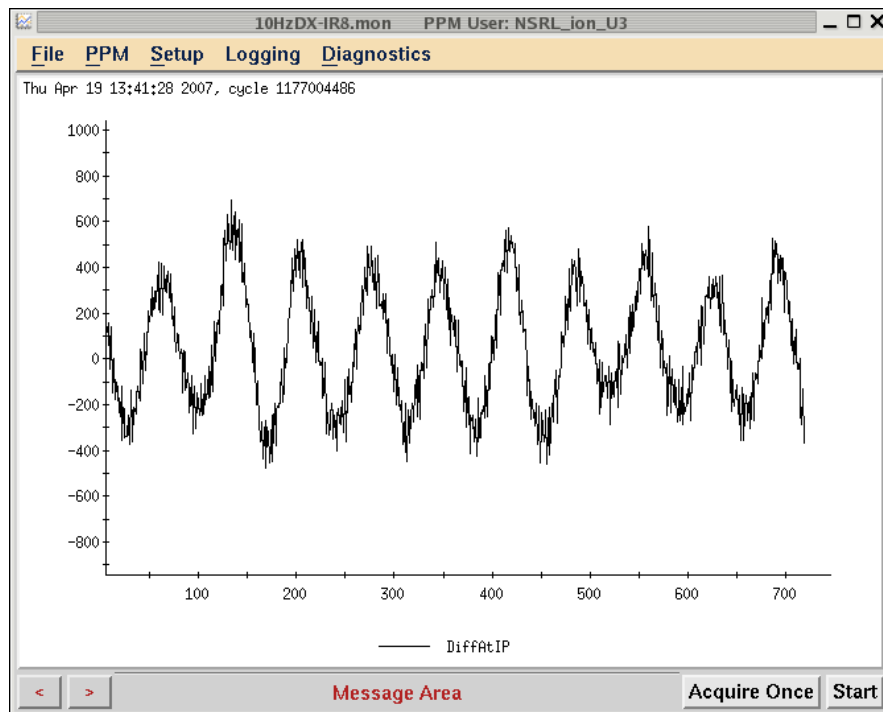
- ▶ Non-linear chromaticity correction: implemented in the current Au-Au Run
- ▶ 3Qx resonance correction: under study
- ▶ Explore new working points
 - ▶ (0.92, 0.93): Christoph
 - ▶ (0.08, 0.07): Wolfram
 - ▶ DA tracking: Christoph and Yun
 - ▶ Spin tracking: Mei, Alfredo
 - ▶ This will be first commissioned during the 2008 pp 100GeV run

▶ Triplet 10 Hz vibration

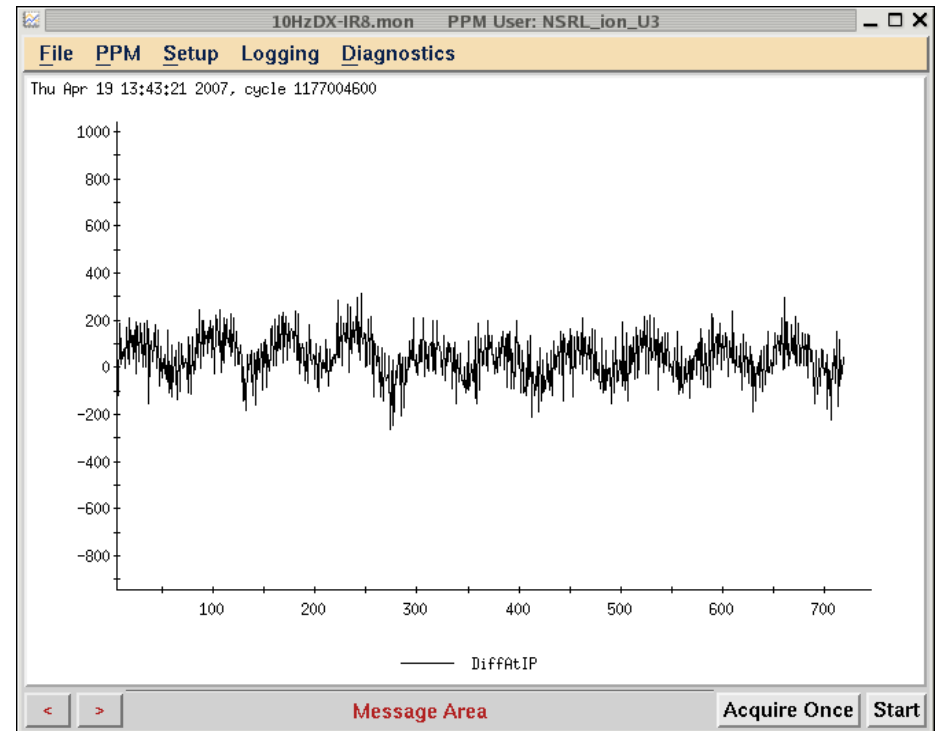
- ▶ 10 Hz orbit feedback
- ▶ Rebuild triplet assembly to reduce the 10Hz

10 Hz orbit feedback

feedback OFF



Feedback ON



Courtesy of Christoph and Angelika

Polarized proton development plan

- ▶ **Polarization:**

- ▶ Improve the orbit control to achieve an orbit distortion of 0.3mm or better during the acceleration from 100 GeV to 250 GeV
- ▶ Improve the betatron tune and coupling control:
Tune/coupling feedback
- ▶ Snake current setting: spin tune measurement

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